PM50

Version 2.0

Power Module for DC, Brushless DC and AC Motors

TECHNOSOFT

DSP Motion Solutions

User Manual

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PM50 v2.0
User Manual

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Read This First

About This Manual

This book describes the power module **PM50 version 2.0**. The PM50 v2.0 is a 75W-power module that can be used to drive DC brush, brushless DC and AC motors. Due to the MC-Bus compatible interface for the control unit, the PM50 v2.0 can be easily connected with all Technosoft DSP-based modules equipped with MC-Bus interface.

Information about Cautions

This book may contain cautions.

CAUTION ! This is an example of a warning statement.
A warning statement describes a situation that could potentially cause harm to you or to the PM50 v2.0 power module

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Note: You need to register your PM50 v2.0 system in order to get free assistance and support.

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1. Introduction

This chapter provides a general description of the PM50 v2.0 power module along with a block diagram and the key features

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1.1. PM50 v2.0 Overview

1.2. Block Diagram

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1.1. PM50 v2.0 Overview

The PM50 v2.0 is a 75W MC-Bus compatible power module, which combined with a control unit, allows to drive the following categories of motors:

- brushless DC motors
- permanent magnet synchronous motors (PMSM)
- DC brush motors

The PM50 v2.0 includes the following main components:

- 3-phase MOSFET inverter: 36 V, 2.1 A, up to 100 kHz switching frequency
- 3 currents feedback, measured from the low-side legs of the inverter
- DC-bus voltage feedback
- Hall sensors inputs
- Incremental encoder port
- RS-232 serial communication connector
- Logical supply: $5V_{DC}$
- Motor supply: $12 – 36V_{DC}$
- Protections to short-circuit, over-current, over-voltage and accidental logic supply shutdown
- Standard MC-Bus interface with the control unit

Through the MC-bus interface the control unit can:

- Command each of the 6 MOSFET transistors of the inverter
- Receive a power stage error signal when the protections are triggered and the inverter transistors are turned-off
- Read the motor currents and the DC-bus voltage
- Read the motor Hall signals
- Read the encoder quadrature signals A, B and the Index
- Control the RS-232 serial communication

At MC-bus level, the MOSFET transistor commands and the power stage error signal are TTL/CMOS compatible. Bipolar signals, as motor currents, are applied with half scale offset, e.g. with zero value at 2.5V.

Due to the MC-bus compatibility, the PM50 v2.0 can be easily connected with any Technosoft DSP-based control unit.

1.2. Block Diagram

Figure 1.1 presents the block diagram of the PM50 v2.0 including the main components.

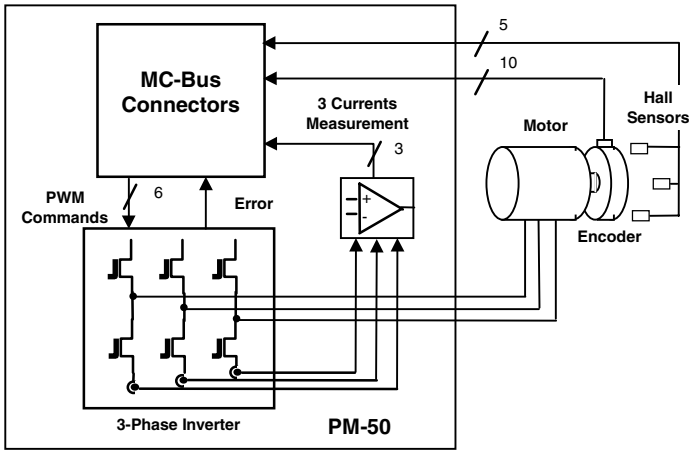

Figure 1.1. PM50 v2.0 Block Diagram

1.3. Key Features

- MC-bus compatible power module, easy connectable with any Technosoft DSP-based control module
- Suitable to drive brushless DC, brushless AC (PMSM) and DC motors
- Logic supply: $+5V_{DC}$ (±5%)
- Motor supply: $12 – 36V_{DC}$
- Nominal output power: 75W
- Nominal current: 2.1A
- Peak current: 6.33A, for 0.1s
- Output voltage: 0 ÷ 36 Vrms
- 3-phase MOSFET inverter with switching frequency up to 100 kHz
- Protection to short-circuit (phase-phase), over-current and over-voltage
- Protection to logic supply under-voltage / accidental shutdown
- Feedback signals for 3 motor currents
- Feedback for DC bus voltage
- Single-ended encoder inputs
- Hall sensors inputs
- RS-232 serial communication port
- Standard MC-BUS interface with the control unit

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2. PM50 v2.0 Operation

This chapter describes the operation of the PM50 v2.0 power module. Information is provided on the PM50's various interfaces.

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2.6 JP1 – Jumper

2.1. Board Layout

Figure 2.1 presents the PM50 v2.0 board layout. Pin 1 for all the connectors and the jumper is marked on the layout with a square pad.

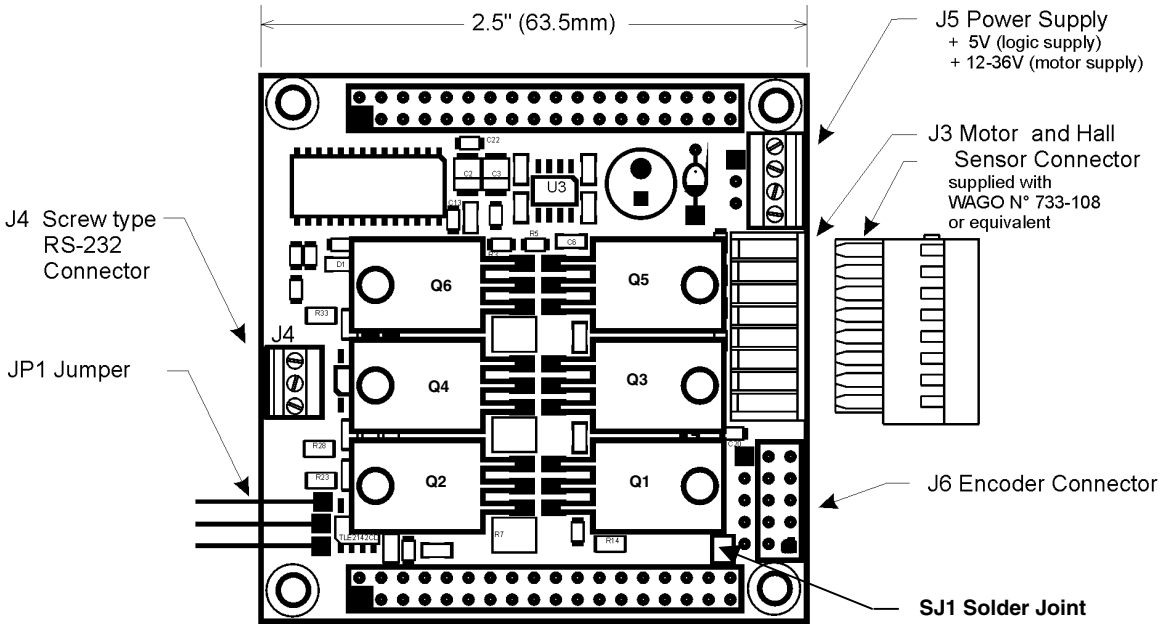

Figure 2.1. *PM50 v2.0 Board Layout*

2.2. Power Supply

2.2.1. J5 – Supply Connector

The PM50 v2.0 requires two power supplies:

- $5V_{DC}$ for the internal logic
- 12 – 36 V_{DC} for the motor

The motor power supply is applied on the inverter DC-bus and must be adapted to the motor and application requirements. It should be able to absorb the energy generated during motor braking. At power-on, the logic supply has to be applied first. If this condition is not respected, the protection for accidental logic supply shutdown will be triggered.

CAUTION !
Be careful to correctly connect the power supplies polarities! Reverse polarities may damage the PM50 module!

By default, the PM50 v2.0 is equipped with a 4-pin 0.1" pitch screw-terminal connector for the supply. Its pin assignment is presented in Table 2.1.

Table 2.1. *J5 – Supply Connector (default): 4-pin 0.1" pitch screw-terminal connector*

Pin	Name	Type	Function
1	+5	I	5V power supply plus (+)
2	GND	I	5V power supply minus (-)
3	GND	I	Motor power supply minus (-)
4	+MOT	I	Motor power supply plus (+)

On request the PM50 v2.0 can also be equipped with 2 other types of connectors for the supply:
- a 3-pin 0.1" pitch Wago 90° connector (J55). Its pin assignment is presented in Table 2.2
- a 4-pin 0.1" pitch Molex 90° connector (J555) with the same pin assignment as J5

Table 2.2. *J55 – Supply Connector (alternate option): 3-pin 0.1" pitch Wago 90° connector*

Pin	Name	Type	Function
1	+5	I	5V power supply plus (+)
2	GND	I	Common supply minus (-)
3	+MOT	I	Motor power supply plus (+)

2.3. Power Stage Module

The PM50 v2.0 power stage module includes a 3-phase inverter, the protection circuits and the measurement circuits for the DC-bus voltage and the motor currents.

2.3.1. 3-phase Inverter Command

The 3-phase inverter (see figure 2.2) uses MOSFET transistors with switching frequency up to 100kHz. The PM50 v2.0 MC-bus interface includes 6 PWM command inputs (TTL/CMOS compatible) named $\overline{\text{PWM1}}$ to $\overline{\text{PWM6}}$ through which the control unit can drive each transistor of the inverter.

All PWM commands are active low. $\overline{\text{PWM1}}$, $\overline{\text{PWM3}}$, $\overline{\text{PWM5}}$ drive the upper transistors. $\overline{\text{PWM2}}$, $\overline{\text{PWM4}}$, $\overline{\text{PWM6}}$ drive the lower transistors. $\overline{\text{PWM1}}$ & $\overline{\text{PWM2}}$ drive phase A, $\overline{\text{PWM3}}$ & $\overline{\text{PWM4}}$ drive phase B, $\overline{\text{PWM5}}$ & $\overline{\text{PWM6}}$ drive phase C. The control unit PWM commands should include a dead-time of minimum 0.5μs for transistor's commutation.

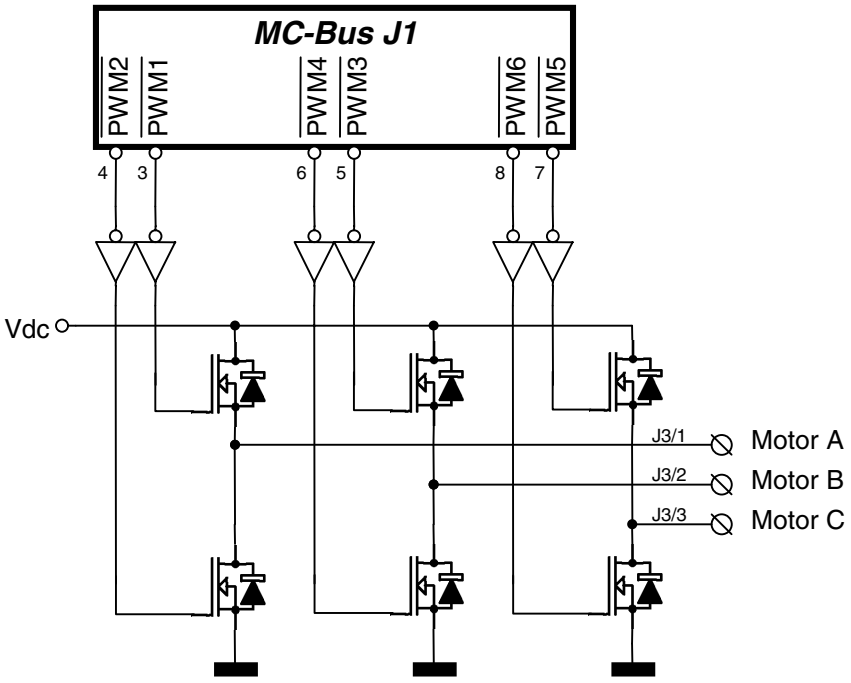

Figure 2.2. *3-phase Inverter Control using PWM Command Inputs*

2.3.2. Protections. Error Signal

The PM50 v2.0 power stage includes protection circuits for: phase to phase short-circuit, over-current, over-voltage and accidental shutdown of logic supply (logic supply under-voltage). If any of these protections is triggered, the PM50 v2.0 sets low the MC-bus error signal $\overline{\text{PDPINT}}$ (open-collector signal) to sign this event to the control unit and the inverter transistors are turned off as long as the condition is maintained. If any low-leg motor current exceeds 7A for more than 10 ms, a $\overline{\text{PDPINT}}$ fault signal will occur. Short-term over-voltages having energy of less than 3J (47V $\times$ 5A $\times$ 12ms) will be clamped by an on-board 47V suppresser.

2.3.3. Current Measurement Interface

The PM50 v2.0 measures the motor currents using shunts placed in the lower-legs of the inverter (see Figure 2.3) using a current gain factor of 0.395V/A, which translates +/-6.33A currents into +/-2.5V voltages. These voltages are applied on the MC-bus analogue outputs IA, IB and IC with a 2.5V offset. Hence positive currents are measured between 2.5V to 5V and negative currents are measured between 0 and 2.5V. The midpoint 2.5V corresponds to a zero current.

Remark: A positive current is defined as flowing from the lower transistor/diode to ground e.g. when the motor sinks the current. A negative current is defined as flowing from ground to the lower transistor/diode e.g. when the motor sources the power supply.

WARNING: Be aware that the current measurement scheme, simple and cost-effective from the hardware point of view, requires some special care from the point of view of software implementation. Thus, for the three currents measurement scheme, the A/D conversion **MUST** be synchronized with the PWM command of the inverter transistors, to properly measure the currents on each phase of the motor.

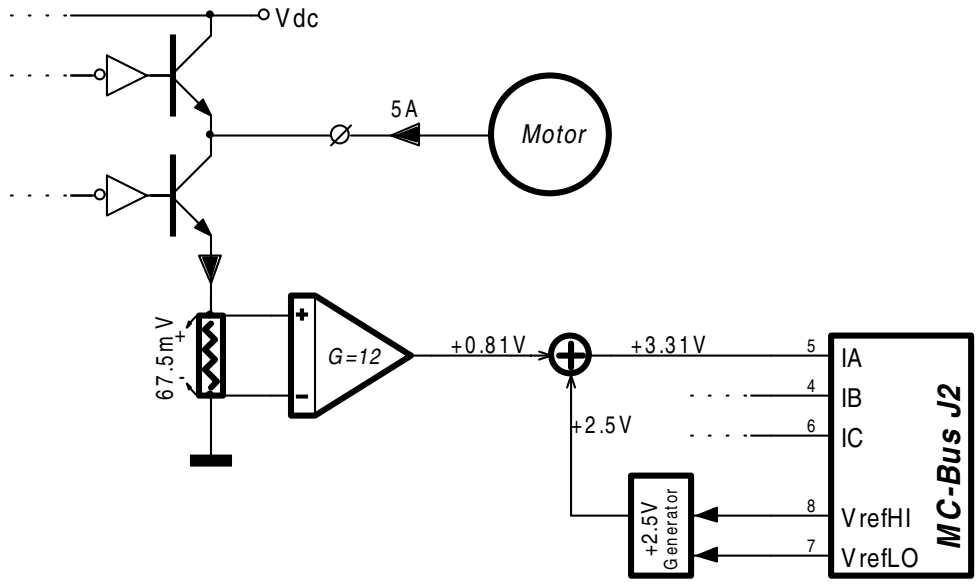

Figure 2.3. *Current Measurement*

2.3.4. Motor Supply / DC-bus Voltage Measurement

The PM-50 v 2.0 includes a motor supply / DC-bus voltage feedback applied on the MC-bus analogue input named VDC. The gain factor is 0.091. Hence, DC-bus voltages between 0 and 55V are translated into 0 to 5V at VDC output.

The measurement scheme provides filtering with a time constant of 8.6 ms, in order to remove spurious switching noise generated by the on-board power stage.

2.3.5. J3 – Motor and Hall Sensors Connector

By default, the PM50 v2.0 is equipped with an 8-pin 0.1” pitch Wago 90° connector for the motor. Its pin assignment is presented in Table 2.3. On request, the PM50 v2.0 can also be equipped with an 8-pin 0.1” pitch screw-terminal connector (J33) with the same pin assignment as J3.

Table 2.3. *J3 – Motor Connector (default): 8-pin 0.1" pitch Wago 90° connector*

Pin	Name	Type	Function
1	U	O	Phase A for 3-phase motors
2	V	O	Phase B for 3-phase motors
3	W	O	Phase C for 3-phase motors
4	+5V	O	$+5V_{DC}$ for Hall sensors
5	HALL1	I	Hall 1
6	HALL2	I	Hall 2
7	HALL3	I	Hall 3
8	GND		Ground

2.3.6. J6 – Encoder Connector

By default, the PM50 v2.0 is equipped with a 2x5 0.1" pitch header connector for the encoder. Its pin assignment is presented in Table 2.4. The encoder connector can be configured from **SJ1** solder joint to be compatible with API-Portescap A22 encoders or Hewlett Packard/Agilent HEDL65xx encoders. The **SJ1** solder joint must be:

- **ON** for HP HEDL65xx encoder type
- **OFF** for API-Portescap A22 encoder type (default)

Table 2.4. *J6 – Encoder Connector (default): 2x5 0.1" pitch header connector*

Pin	Name	Type	Function
1	GND		Ground
2	+5V	O	Encoder supply
3	DIR		Connected to ground if SJ1 = ON (see note)
4	$\overline{\text{STBY}}$	I	Connected to +5V
5	-	n.c.	Not connected
6	A	I	Positive A for differential encoder or A for single-ended encoder
7	-	n.c.	Not connected
8	B	I	Positive B for differential encoder or B for single-ended encoder
9	-	n.c.	Not connected
10	Z	I	Positive Z for differential encoder or Z for single-ended encoder

Table 2.5. *J66 – Encoder Connector (alternate option): 5-pin Molex connector*

Pin	Name	Type	Function
1	GND		Ground
2	Z	I	Positive Z for differential encoder or Z for single-ended encoder
3	A	I	Positive A for differential encoder or A for single-ended encoder
4	+5V	O	Encoder sensor supply
5	B	I	Positive B for differential encoder or B for single-ended encoder

On request, the PM50 v2.0 can also be equipped with a vertical (J666) or 90° (J66) 5-pin Molex connector for the encoder, which is compatible with all Hewlett Packard/Agilent HEDSxxxx single-ended TTL-compatible encoders. Table 2.5 presents the pin assignment the for Molex connectors.

2.4. Communication

2.4.1. J4 – RS-232 Connector

The PM50 v2.0 power module offers an RS-232 serial channel. The control unit must provide on the MC-bus interface the Rx232 and Tx232 signals. The PM50 v2.0 applies them to the 3-wire RS-232 connector. The RS-232 transceiver should be on the control unit.

By default, the PM50 v2.0 is equipped with a 3-pin 0.1" pitch screw-terminal connector for RS-232 link. Its pin assignment is presented in Table 2.6. On request, the PM50 v2.0 can also be equipped with a 0.15" pitch Phoenix Contact Plug connector type MC1.5/3-G-3.81 with the same pin out as J4.

Table 2.6. *J4 – RS-232 Connector (default): 3-pin 0.1" pitch screw-terminal connector*

Pin	Name	Type	Function
1	TxD	O	Data Transmission
2	GND		Ground
3	RxD	I	Data Reception

A serial cable between the PM50 v2.0 power module and a PC must have the connections described in Table 2.7.

Table 2.7. *RS-232 serial cable connections*

Signal Name	Pin Assignments		
	PC side		PM50 v2.0side
	DB25 Female	DB9 Female	J4 or J44 connectors
Transmit Data	2	3	1
Receive Data	3	2	3
Signal ground	7	5	2

2.5. Control Unit Interface (MC-Bus)

2.5.1. J1, J2 – MC-Bus Connectors

The PM50 v2.0 power module receives the PWM command signals and sends the feedback and status signals to the control unit through the two 2x18-pin 0.1" pitch MC-Bus connectors J1 and J2. The MC-Bus is a standard interface that permits to connect different Technosoft control and measurement modules with a range of power modules including PM50 v2.0. Tables 2.8 and 2.9 present the PM50 v2.0 pin assignment on the MC-Bus connectors. By default, the PM50v2.0 is

delivered with PC-104 connectors on the MC-Bus, to allow control unit connecting either over or under the PM50 v2.0.

Table 2.8. *J1 – MC-bus connector*

Pin	Name	Type	Description
1	-reserved-	n.c.	Not connected on the PM50 v2.0
2	-reserved-	n.c.	
3	$\overline{PWM1}$	I[1]	CU[2] output. Active low command for the upper transistor, A-phase leg
4	$\overline{PWM2}$	I	CU output. Active low command for the lower transistor, A-phase leg
5	$\overline{PWM3}$	I	CU output. Active low command for the upper transistor, B-phase leg
6	$\overline{PWM4}$	I	CU output. Active low command for the lower transistor, B-phase leg
7	$\overline{PWM5}$	I	CU output. Active low command for the upper transistor, C-phase leg
8	$\overline{PWM6}$	I	CU output. Active low command for the lower transistor, C-phase leg
9	-reserved-	n.c.	Not connected on the PM50 v2.0
10	-reserved-	n.c.	Not connected on the PM50 v2.0
11	-reserved-	n.c.	Not connected on the PM50 v2.0
12	-reserved-	n.c.	Not connected on the PM50 v2.0
13	-reserved-	n.c.	Not connected on the PM50 v2.0
14	-reserved-	n.c.	Not connected on the PM50 v2.0
15	-reserved-	n.c.	Not connected on the PM50 v2.0
16	-reserved-	n.c.	Not connected on the PM50 v2.0
17	ENC-A	O[3]	CU input. Encoder signal A from J6, J66 or J666
18	ENC-B	O	CU input. Encoder signal B from J6, J66 or J666
19	ENC-Z	O	CU input. Encoder signal Z (index/zero) from J6, J66 or J666
20	-reserved-	n.c.	Not connected on the PM50 v2.0
21	$\overline{PDPINT}$	O	CU input. Power stage error signal, driven by protection circuitry. Open-collector signal
22	-reserved-	n.c.	Not connected on the PM50 v2.0
23	-reserved-	n.c.	
24	-reserved-	n.c.	
25	$+5V_{DC}$	O	$+5V_{DC}$ from J5 or J55 connectors
26	DGND		Ground terminal. All digital signals are referenced to this signal
27	DGND		
28	DGND		
29	DGND		
30	-reserved-	n.c.	Not connected on the PM50 v2.0
31	-reserved-	n.c.	
32	-reserved-	n.c.	
33	-reserved-	n.c.	
34	-reserved-	n.c.	
35	-reserved-	n.c.	
36	-reserved-	n.c.	

[1] I – input in PM50 v2.0, output from control unit
[2] CU – control unit connected through the MC-bus with PM50 v2.0
[3] O – output from PM50 v2.0, input in CU

Table 2.9. *J2 – MC-bus connector*

Pin	Name	Type	Description
1	-reserved-	n.c.	Not connected on the PM50 v2.0
2	-reserved-	n.c.	
3	VDC	O	CU analog input. Value of the motor supply / DC-bus voltage. Gain factor is 91mV/V
4	IB	O	CU analog input. Value of current in B-phase inverter lower leg, upper shifted with 2.5V. Gain factor is 0.395V/A
5	IA	O	CU analog input. Value of current in A-phase inverter lower leg, upper shifted with 2.5V. Gain factor is 0.395V/A
6	IC	O	CU analog input. Value of current in C-phase inverter lower leg, upper shifted with 2.5V. Gain factor is 0.395V/A
7	V_{REF}LO	O	Analogue ground. Separated from DGND. The connection between these two signals must be done on the CU
8	$+5V_A$	I	Analogue reference. CU must provide the $+5V_A$. Half of this value represents the upper shift for bipolar signals. Typical expected value is +5V, allowed range is +4.75…5.25V.Current drawn by PM50 v2.0 is under 0.5 mA
9	DGND		Ground terminal. All digital signals are referenced to this signal
10	DGND		
11	Hall 1	O	CU input. HALL1 signal from J3 or J33 connectors
12	-reserved-	n.c.	Not connected on the PM50 v2.0
13	Hall 2	O	CU input. HALL2 signal from J3 or J33 connectors
14	Hall 3	O	CU input. HALL3 signal from J3 or J33 connectors
15	DGND		Ground terminal. All digital signals are referenced to this signal
16	-reserved-	n.c.	Not connected on the PM50 v2.0
17	Rx232	O	CU RS-232 input linked directly to J4 or J44 connectors pin 3
18	Tx232	I	CU RS-232 output, linked directly to J4 or J44 connectors pin 1
19	-reserved-	n.c.	Not connected on the PM50 v2.0
20	-reserved-	n.c.	
21	$+5V_{DC}$	O	$+5V_{DC}$ from J5 or J55 connectors
22	$+5V_{DC}$	O	
23	-reserved-	n.c.	Not connected on the PM50 v2.0
24	-reserved-	n.c.	Not connected on the PM50 v2.0
25	-reserved-	n.c.	Not connected on the PM50 v2.0
26	-reserved-	n.c.	Not connected on the PM50 v2.0
27	-reserved-	n.c.	Not connected on the PM50 v2.0
28	-reserved-	n.c.	Not connected on the PM50 v2.0
29	-reserved-	n.c.	Not connected on the PM50 v2.0
30	-reserved-	n.c.	Not connected on the PM50 v2.0
31	In	O	CU input. Provides JP1 position: 1 logic -> JP1 =1-2, 0 logic -> JP1=2-3
32	-reserved-	n.c.	Not connected on the PM50 v2.0
33	-reserved-	n.c.	Not connected on the PM50 v2.0
34	-reserved-	n.c.	Not connected on the PM50 v2.0
35	-reserved-	n.c.	Not connected on the PM50 v2.0
36	-reserved-	n.c.	Not connected on the PM50 v2.0

2.6. JP1 - Jumper

The PM50 v2.0 power module provides one jumper JP1 whose position determines the level of the digital input In connected to the MC-Bus:

- JP1 = 1-2, In signal is high (1 logic)
- JP2 = 2-3, In signal is low (0 logic)

Appendices

Appendix A. PM50 v2.0 Electrical Specifications

Parameter	Conditions	Min.	Typ.	Max.	Units
DC Input Power					
Logic supply		4.5	5	5.5	V
Motor supply		1		36	V
Logic input current	Required by PM50 v2.0 only. For total rating, add the control unit current			0.15	A
Motor supply current				2.1	Arms
Motor supply current				6.33	Apeak
Output Power					
Voltage	set by external PWM control	0		36	Vrms
Nominal Motor Power	V_{in}=36V, f_{pwm}=20kHz, T_A=40°C			75	W
Nominal Motor Current	T_A=40°C			1.7	Arms
Overload Motor Current	V_{in}=36V, nominal full load current, f_{pwm}=20kHz, 0.1 sec. duration			6.33	Apeak
PWM frequency		0.1	20	100	kHz
Inverter output dead band	Measured at inverter outputs using PWM commands with dead time of 0.5 µs, T_A = 25ºC		0.2		µs
Protections					
Output current trip level	T_C = 25ºC			7	Apeak
Over-voltage trip level		44	47	50	V
Under-voltage trip level	Referring to internal +12V supply, derived from logic supply (+5V)	10		11	V
Short circuit shutdown time	Output terminals shorted		0.5		ms
Inputs from MC-BUS					
PWM dead band command	Measured at MC-BUS pins, over operating ambient temperature	0.2	0.5		µs
High level input voltage	TTL compatible	2			V
Low level input voltage	TTL compatible			0.8	V
High level input current	Compatible with open-collector outputs	0		0	mA
Low level input current				2	mA
Analog Outputs to MC-BUS					
Gain of 3 motor currents feedback	Low-side leg inverter current		0.395		V/A
Offset of 3 motor currents feedback		2.375	2.5	2.625	V
Cut-off frequency of 3 motor currents feedback			1.5		MHz

DC bus voltage feedback gain			90.9		mV/V_{BUS}
Cut-off frequency of DC bus voltage			730		Hz
Setting time of the 3 motor currents feedback	0.1% accuracy			400	ns

Digital Outputs to MC-BUS

High level output voltage for Mon/User MC-BUS pin	Direct link to +5V logic supply		5		V
Low level output voltage for Mon/User MC-BUS pin	Direct link to ground		0		V

Hall Inputs from motor connector

High level input current	Pull-up resistor to +5V	0		0	mA
Low level input current				1.2	mA

System Environment

Ambient Operating Temp.	90%RH max. (non-condensing)	0		55	ºC

Appendix B. MC-Bus Pin Correspondence with IMMC240 v3.0 and MCSK v1.0

J1 – MC-bus connector

Pin	PM50 v2.0 signal	IMMC240 signal	MCSK signal
1	n.c.	n.c.	n.c.
2	n.c.	n.c.	n.c.
3	$\overline{\text{PWM1}}$	PWM1	$\overline{\text{PWM1}}$
4	$\overline{\text{PWM2}}$	PWM2	$\overline{\text{PWM2}}$
5	$\overline{\text{PWM3}}$	PWM3	$\overline{\text{PWM3}}$
6	$\overline{\text{PWM4}}$	PWM4	$\overline{\text{PWM4}}$
7	$\overline{\text{PWM5}}$	PWM5	$\overline{\text{PWM5}}$
8	$\overline{\text{PWM6}}$	PWM6	$\overline{\text{PWM6}}$
9	n.c.	CMP7 / IOPB0	IO#4/ $\overline{\text{BRAKE}}$
10	n.c.	CMP8 / IOPB1	IO#5
11	n.c.	CMP9 / IOPB2	IO#6
12	n.c.	T1CMP / IOPB3	IO#7
13	n.c.	T2CMP / IOPB4	IO#8
14	n.c.	T3CMP / IOPB5	IO#9
15	n.c.	TMRDIR / IOPB6	IO#10/DIR
16	n.c.	TMRCLK / IOPB7	IO#11/PULSE
17	ENC-A	QEP1 / IOPC4	IO#16/ENCA
18	ENC-B	QEP2 / IOPC5	IO#17/ENCB
19	ENC-Z	CAP3 / IOPC6	IO#18/CAPI/HALL1
20	n.c.	CAP4 / IOPC7	IO#19/CAPH/DIR
21	$\overline{\text{PDPINT}}$	$\overline{\text{PDPINT}}$	$\overline{\text{PDPINT}}$
22	n.c.	XINT2 / IO	LSP
23	n.c.	SCIRXD / IO	SCIRXD
24	n.c.	SCITXD / IO	SCITXD
25	$+5V_{DC}$	$+5V_{DC}$	$+5V_{DC}$
26	DGND	DGND	DGND
27	DGND	DGND	DGND
28	DGND	DGND	DGND
29	DGND	DGND	DGND
30	n.c.	VrefLO	V_{REF}LO
31	n.c.	ADCIN5	TEMP1/TQLIM/ADCIN5
32	n.c.	ADCIN13	n.c.
33	n.c.	ADCIN6	FEEDBACK/ADCIN6
34	n.c.	ADCIN14	REFERENCE/ADCIN14
35	n.c.	ADCIN7	ADCIN7
36	n.c.	ADCIN15	TEMP2/TQFFW/ADCIN15

J2 – MC-bus connector

Pin	PM50 v2.0 signal	IMMC240 signal	MCSK signal
1	n.c.	ADCIN2	CFG/ADCIN2
2	n.c.	ADCIN10	ADCIN10
3	VDC	ADCIN3	VDC/ADCIN3
4	IV	ADCIN11	IB/ADCIN11
5	IU	ADCIN4	IA/ADCIN4
6	IW	ADCIN12	IC/ADCIN12
7	V_{REF}LO	V_{REF}LO	V_{REF}LO
8	V_{REF}HI	V_{REF}HI	V_{REF}HI
9	DGND	DGND	DGND
10	DGND	DGND	DGND
11	Hall 1	IOPA0	IO#0/HALL1
12	n.c.	IOPA3	IO#3/TXEN485
13	Hall 2	IOPA1	IO#1/HALL2
14	Hall 3	IOPA2	IO#2/HALL3
15	DGND	DGND	DGND
16	n.c.	DGND	DGND
17	Rx232	RX	RxD
18	Tx232	TX	TxD
19	n.c.	n.c.	n.c.
20	n.c.	n.c.	n.c.
21	$+5V_{DC}$	$+5V_{DC}$	$+5V_{DC}$
22	$+5V_{DC}$	$+5V_{DC}$	$+5V_{DC}$
23	n.c.	PORESET	$\overline{\text{PORESET}}$
24	n.c.	- reserved -	V_{EE}
25	n.c.	- reserved -	n.c.
26	n.c.	- reserved -	n.c.
27	n.c.	SPISIMO / IO	SPISIMO
28	n.c.	SPISOMI / IO	SPISOMI
29	n.c.	SPICLK / IO	SPICLK
30	n.c.	SPISTE / IO	SPISTE
31	In	ADCSOC / IOPC0	$\overline{\text{AUTORUN}}$
32	n.c.	CLKOUT / IOPC1	CLKOUT/IO#13
33	n.c.	XF / IOPC2	$\overline{\text{MCRDY}}$
34	n.c.	BIO / IOPC3	$\overline{\text{INT2HOST}}$
35	n.c.	XINT3 / IO	LSN
36	n.c.	NMI	ENABLE

Appendix C. MC-Bus Pin Correspondence with MSK243 v1.1

J1 – MC-bus connector

Pin	PM50 v2.0 signal	MSK243 signal
1	n.c.	n.c.
2	n.c.	n.c.
3	$\overline{\text{PWM1}}$	PWM1
4	$\overline{\text{PWM2}}$	PWM2
5	$\overline{\text{PWM3}}$	PWM3
6	$\overline{\text{PWM4}}$	PWM4
7	$\overline{\text{PWM5}}$	PWM5
8	$\overline{\text{PWM6}}$	PWM6
9	n.c.	IOPD2
10	n.c.	IOPD3
11	n.c.	IOPD4
12	n.c.	T1CMP / IOPB4
13	n.c.	T2CMP / IOPB5
14	n.c.	IOPD5
15	n.c.	TMRDIR / IOPB6
16	n.c.	TMRCLK / IOPB7
17	ENC-A	QEP1 / IOPA3
18	ENC-B	QEP2 / IOPA4
19	ENC-Z	CAP3 / IOPA5
20	n.c.	IOPD6
21	$\overline{\text{PDPINT}}$	$\overline{\text{PDPINT}}$
22	n.c.	XINT2 / IOPD1
23	n.c.	SCIRXD / IOPA1
24	n.c.	SCITXD / IOPA0
25	$+5V_{DC}$	$+5V_{DC}$
26	DGND	DGND
27	DGND	DGND
28	DGND	DGND
29	DGND	DGND
30	n.c.	VrefLO
31	n.c.	- n.c. - (ADCIN4)
32	n.c.	n.c.
33	n.c.	ADCIN0
34	n.c.	ADCIN1
35	n.c.	ADCIN2
36	n.c.	ADCIN3

J2 – MC-bus connector

Pin	PM50 v2.0 signal	MSK243 signal
1	n.c.	n.c.
2	n.c.	n.c.
3	VDC	ADCIN4
4	IV	ADCIN5
5	IU	ADCIN6
6	IW	ADCIN7
7	V_{REF}LO	VrefLO
8	V_{REF}HI	VrefHI
9	DGND	DGND
10	DGND	DGND
11	Hall 1	n.c. (see remark)
12	n.c.	n.c.
13	Hall 2	n.c. (see remark)
14	Hall 3	n.c. (see remark)
15	DGND	DGND
16	n.c.	DGND
17	Rx232	RxD
18	Tx232	TxD
19	n.c.	CAN_HI
20	n.c.	CAN_VCC
21	$+5V_{DC}$	$+5V_{DC}$
22	$+5V_{DC}$	$+5V_{DC}$
23	n.c.	$\overline{\text{PORESET}}$
24	n.c.	n.c.
25	n.c.	CAN_LO
26	n.c.	CAN_GND
27	n.c.	SPISIMO / IOPC2
28	n.c.	SPISOMI / IOPC3
29	n.c.	SPICLK / IOPC4
30	n.c.	SPISTE / IOPC5
31	Mon/User	IOPD7
32	n.c.	CLKOUT / IOPD0
33	n.c.	XF / IOPC0
34	n.c.	BIO / IOPC1
35	n.c.	XINT1 / IOPA2
36	n.c.	$\overline{\text{NMI}}$

Remark: When MSK243v1.1 is delivered together with a PM50 v2.0, the MSK243 board includes an adapter. The adapter links the following MC-Bus signals: a) J2/pin 11 with J1/pin 11, b) J2/pin

13 with J1/pin14, c) J2/pin 14 with J1/pin 20. These links connect the Hall signals from PM50 v2.0 MC-Bus with three I/O pins of the MSK243.

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